

Alessandro Garassino (*)

The macruran decapod crustaceans of the Lower Cretaceous (Lower Barremian) of Las Hoyas (Cuenca, Spain)

Abstract - The macruran decapod crustaceans of the Lower Cretaceous (Lower Barremian) of Las Hoyas have already been the subject of a study at the beginning of the 90s. The examined specimens were ascribed to the species *Delclosia martinelli* Rabadà, 1993 (infraorder Caridea Dana, 1852, indeterminate family) and *Pseudastacus llopisi* Via, 1971 (infraorder Astacidea Latreille, 1803, family Nephropidae Dana, 1852) respectively. The analysis of the wide sample of macruran decapod crustaceans, housed in the Autonomous University of Madrid and in the private collection of Mr. Armando Díaz-Romeral, allowed to carry out a detailed morphological description of both species, by emphasizing new features previously not observed and deepening the analysis of other features already known in the past. Unlike the original description, the study of the examined sample has so allowed the ascription and systematic revision of the two species: in fact *Delclosia martinelli* Rabadà, 1993 has been ascribed to the family Atyidae de Haan, 1849 while *Pseudastacus llopisi* Via, 1971 has been ascribed to the living genus *Austrapotamobius* Skorikov, 1907 (family Astacidae Latreille, 1802) on the basis of some common features, such as the structure of the chela of pereopod 1, the number of postorbital teeth and the structure of the tail fan. The presence of *Austrapotamobius* Skorikov, 1907 in Las Hoyas outcrop represents the first report of this genus in the fossil record.

Resumen - Los crustáceos decápodos macruros del Cretácico inferior de Las Hoyas (Cuenca, España).

Los crustáceos decápodos macruros del Cretácico inferior de Las Hoyas (Cuenca, España) han sido ya objeto de estudio desde los primeros años noventa de parte de Rabadà (1993). Los ejemplares fueron atribuidos respectivamente a la especie *Delclosia martinelli* Rabadà, 1993 (infraorden Caridea Dana, 1852, familia indeterminada) y *Pseudastacus llopisi* Via, 1971 (infraorden Astacidea Latreille, 1803, familia Nephropidae Dana, 1852). El análisis del abundante muestra de crustáceos decápodos macruros, conservados en la Universidad Autónoma de Madrid y de la colección privada del Sr. Armando Díaz-Romeral, ha echo posible la revisión y atribución sistemática de las dos especies: *Delclosia martinelli* Rabadà, 1993 ha sido asignada correctamente a la familia Atyidae de Haan, 1849, mientras que *Pseudastacus llopisi* Via, 1917 acaba de ser atribuida al género viviente *Austrapotamobius* Skorikov, 1907 (familia Astacidae Latreille, 1802), gratias ad alguna característica común, cómo el rostro con un diente supraoral, un sólo diente postorbital, la quela del pereiópodo I con un evidente escalón en el margen interno del index que se corresponde con la articulación con el dactilo y el telson, subdividido en dos partes con forma de uña transversal. La existencia de género *Austrapotamobius* Skorikov, 1907 en el yacimiento de Las Hoyas representa su primer indicio en el registro fósil.

(*) Museo Civico di Storia Naturale, C.so Venezia, 55 - 20121 Milano, Italia

Riassunto -I Crostacei decapodi macruri del Cretacico inferiore (Barremiano inferiore) di Las Hoyas (Cuenca, Spagna).

I crostacei decapodi macruri del Cretacico inferiore (Barremiano inferiore) di Las Hoyas (Cuenca, Spagna) sono già stati oggetto di studio nei primi anni novanta. Gli esemplari esaminati furono attribuiti rispettivamente alle specie *Delclosia martinelli* Rabadà, 1993 (infraordine Caridea Dana, 1852, famiglia indeterminata) e *Pseudastacus llopisi*, Via, 1971 (infraordine Astacidea Latreille, 1803, famiglia Nephropidae Dana, 1852). L'analisi dell'abbondante campione di crostacei decapodi macruri, conservato all'Università Autonoma di Madrid e nella collezione privata del Sig. Armando Díaz-Romeral, ha reso possibile una accurata descrizione morfologica di entrambe le specie nella quale vengono evidenziati nuovi caratteri non osservati in precedenza, approfondendone altresì l'analisi di altri già conosciuti in passato. Rispetto alla descrizione originale, lo studio del campione esaminato ha reso così possibile l'attribuzione e revisione sistematica delle due specie: *Delclosia martinelli* Rabadà, 1993 è stata infatti assegnata alla famiglia Atyidae de Haan, 1849 mentre *Pseudastacus llopisi*, Via, 1971 viene attribuita al genere vivente *Austropotamobius* Skorikov, 1907 (famiglia Astacidae Latreille, 1802) in base ad alcuni caratteri comuni, quali la struttura della chela del pereopode I, il numero dei denti postorbitali e la struttura del ventaglio caudale. La presenza di *Austropotamobius* Skorikov, 1907 nel giacimento di Las Hoyas rappresenta la prima segnalazione di questo genere nel record fossile.

Key words: Crustacea, Decapoda, Lower Cretaceous, Spain

Introduction

The Lower Cretaceous (Lower Barremian), outcropping in the southern part of the «Serranía de Cuenca» about 30 km E of the city of Cuenca (Fig. 1), consists of two sedimentary cycles: «El Collado» and «La Huérguina» Formations. The Las Hoyas outcrop is located inside «La Huérguina» Formation, characterized by carbonatic deposits originated by continuous accumulations of alluvional and lacustrine materials (Gómez-Fernández & Meléndez, 1991, Fregenal Martínez & Meléndez, 1993 and Fregenal Martínez & Meléndez, 1995).

The numerous excavations, started in 1985 further to a report by Mr Armando Díaz-Romeral, an amateur naturalist, and Mr Santiago Prieto, brought to light a rich vertebrate and invertebrate fauna, typical of lacustrine environment. One of the peculiar features of this outcrop is the perfect state of preservation of the discovered specimens, most of which preserve traces of soft parts and are almost always found articulated.



Fig. 1 - Location of Las Hoyas outcrop (the asterisk shows the outcrop).

The tetrapods, very rare in this outcrop, include anuran amphibia and salamanders (Evans & Milner, 1988 and Evans & Milner, 1995), turtles, lizards belonging to the genus *Ilerdaesaurus* (Barbadillo & Evans, 1995), metasuchian crocodiles with the genus *Lisboasaurus* (Buscalioni & Ortega, 1994 and Ortega & Buscalioni, 1995), remains of ornitomimosaurid dinosaurs, ascribed to the genus *Pelecanimimus* (Pérez-Moreno et alii, 1994 and Pérez-Moreno & Sanz, 1995) and remains of birds, ascribed to the two genera *Iberomesornis* and *Concornis* (Sanz et alii, 1988, Sanz & Bonaparte, 1992, Sanz & Buscalioni, 1992 and Sanz & Buscalioni, 1994).

The most frequent vertebrates in the lithographic limestone are the bony fishes (actinopterygians and sarcopterygians), subject of study of many papers (Poyato-Ariza, 1989, 1991, 1993, 1994, 1995a, 1995b, Poyato-Ariza & Wenz, 1990, Wenz & Poyato-Ariza, 1994, 1995 and in press).

However, the most frequent fossils in Las Hoyas outcrop are represented by crustacean remains: among these, rare and not yet described, there are copepods, probable mysidaceans, peracarids, isopods and ostracodes (Martínez-Delclòs & Nel, 1995 and Rodríguez-Lázaro, 1995); on the contrary, the macruran decapod crustaceans, subject of previous papers (Rabadà, 1990, 1993) are particularly frequent. Among the other invertebrates, bivalves and gastropods are very rare, while insects are usually frequent (Martínez-Delclòs et alii, 1995 and Nel et alii, 1993a, 1993b, 1993c).

Moreover remains of charophytes, briophytes, ferns, cicadophytes (*Zamites*), gnetales (*Drewria*), conifers (*Pagiophyllum*, *Brachyphyllum*, *Shenolepis*, *Cupressinocladus* and *Frenolepis*) and angiosperms were discovered in the outcrop. On the contrary, trackways belonging to invertebrates (Fregeal Martínez et alii, 1995) and vertebrates (Fregeal Martínez & Moratalla, 1995) are very rare.

Previous studies on the macruran decapod crustaceans of Las Hoyas

In the two outcrops, «La Pedrera» and «La Cabrera», of the Lower Cretaceous (Upper Berrisian-Lower Valanginian) of Montsec (Lleida, Barcelona) a freshwater fauna was discovered, similar for many aspects to Las Hoyas association (Lower Barremian). Via (1971) ascribed 13 macruran decapod crustaceans discovered in Montsec outcrops to the two species *Pseudastacus llopisi* (infraorder Astacidea Latreille, 1803, family Nephropidae 1852) and *Oplophorus roselli* (infraorder Caridea Dana, 1852, family Oplophoridae Dana, 1852).

The following discovery of the rich macruran decapod crustaceans fauna in Las Hoyas outcrop allowed to carry out a comparative analysis of the two carcinological faunas. The better state of preservation of the examined specimens allowed Rabadà (1990, 1993) to identify in this outcrop the same species *Pseudastacus llopisi* Via, 1971 and to establish instead the new genus *Delclosia* Rabadà, 1993 with the species *D. martinelli* Rabadà, 1993 (infraorder Caridea Dana, 1852, indeterminate family).

The following comparison between *D. martinelli* Rabadà, 1993 and *Oplophorus roselli* Via, 1971 by Rabadà, pointed out some common features, such as the presence of small chelae in pereopods I-II, the subround shape of the pleura of somite II and the particular elongation of somite VI, which allowed to ascribe the species by Via to the same genus *Delclosia* Rabadà, 1993.

Nowadays, it is difficult to establish if *D. roselli* (Via, 1971) and *D. martinelli* Rabadà, 1993 are two different specific entities or whether they are synonymous, without a careful analysis of the carcinological sample of Montsec.

On the other hand, the original description of the species (Via, 1971, pag. 608; Rabadà, 1993, pag. 354) and their iconographic reconstructions (Via, 1971, fig. 1a; Rabadà, 1993, figs. 3, 4) show a particular morphological feature which leads us to consider them as two distinct species. In fact, *D. roselli* (Via, 1971) has a long and markedly upwards bent rostrum, bearing seven suprarostal teeth in the proximal third while *D. martinelli* Rabadà, 1993 has a long and straight rostrum, bearing at least 25/30 small suprarostal teeth along its whole length.

Preservation modalities and materials

The macruran decapod crustaceans examined in this study are preserved in light-brown densely laminate thin layers of lithographic limestone, flattened on the layer surface. The soft consistency of the surrounding rock makes their preparation easy.

The collections belonging to the Autonomous University of Madrid and to Mr. Armando Díaz-Romeral consist of about 1000 specimens of macruran decapod crustaceans in different states of preservation. The preliminary analysis brought to an initial selection of 83 specimens of *Delclosia martinelli* Rabadà, 1993 and 550 specimens of *Pseudastacus llopsi* Via, 1971. A final sample, the subject of this study, has been subsequently selected from this sample of 633 specimens: it consists of 50 specimens, 22 of which belonging to *Delclosia martinelli* Rabadà, 1993 and 28 to *Pseudastacus llopsi* Via, 1971.

The study on the decapod crustaceans of the Lower Cretaceous of Las Hoyas is part of a research programme on Mesozoic macruran decapod crustaceans that the Invertebrate Palaeontology Department of the Museo di Storia Naturale di Milano has been carrying out for many years on materials from its own and other Museums' collections. Up to now this programme brought to the description of important Italian and foreign Mesozoic faunistic assemblages, such as the Triassic association of the Ambilobè region (NW Madagascar) (Garassino & Teruzzi, 1995), of Cene (Seriana Valley, Bergamo - N Italy) (Pinna, 1974), of Prati di Rest (Valvestino, Brescia - N Italy) (Pinna, 1976), of Ponte Giurino (Imagna Valley, Bergamo - N Italy) (Garassino & Teruzzi, 1993) and of Carnia (Udine, NE Italy) (Garassino, Teruzzi & Dalla Vecchia, 1996); the Lower Jurassic fauna of Osteno (Lugano Lake, Como - N Italy) (Pinna, 1968, 1969; Garassino & Teruzzi, 1990; Teruzzi, 1990 and Garassino, 1996) and the Cretaceous assemblages of Trebiciano (Trieste, NE Italy) (Garassino & Ferrari, 1992), of the Lebanese outcrops (Garassino, 1994), of Vernasso (Udine, NE Italy) (Garassino & Teruzzi, 1995), of Pietraroia (Benevento, S Italy) (Bravi & Garassino, in press), of Petina (Alburni Mounts, Salerno - S Italy) (Bravi & Garassino, in press) and of Torrente Cornappo Valley (Udine, NE Italy) (Garassino, in press).

Abbreviations

R - rostrum	Ex - exopodite
E - eye	di - diaeresis
t - telson	P - propodus
Pt - protopodite	D - dactylus
En - endopodite	I - index

SYSTEMATICS

Infraorder Caridea Dana, 1852

Family Atyidae de Haan, 1849

Genus *Delclosia* Rabadà, 1993

Delclosia martinelli Rabadà, 1993

Figs. 2, 3, 10, 11

1993 - *Delclosia martinelli* - Rabadà, p. 356, Fig. 3, Tab. 1

Diagnosis. Subrectangular carapace; long rostrum with at least 25 forwards protuded suprarostal teeth; pereopods I-II bearing very small chelae; pereopods III-V longer than the preceding ones; somite II with subround pleura overlapping that of somites I and III; somite VI strongly elongate; exopodite with diaeresis.

Material. 144 specimens in different states of preservation belong to the collection of the Autonomous University of Madrid; 22 complete specimens were studied in detail in order to deepen the analysis on this species, which adds new data to the original description by Rabadà (1993), based on a sample of only 9 specimens. 21 specimens are preserved in lateral view and 1 in dorsal view.

LH98, LH206, LH219, LH1122, LH1351, LH1852, LH1855, LH2646, LH2875, LH2923, LH2974, LH3026, LH6948, LH13043, LH13256, LH13323, LH13567, LH14209, LH14294, LH14360, LH14361, LH14362

Description. It is a small-sized caridean with thin and completely smooth exoskeleton, 1.5 to 3 cm in length.

Carapace. In lateral view, the carapace (Fig. 2) has a subrectangular shape and gets slightly narrow toward the anterior margin for the slight curvature of the ventral margin. The dorsal margin is straight, while the posterior margin, strengthened by a thin marginal carina, is slightly sinuous, with a slight concavity in the lower third, partially covering somite I. The ventral margin has a curvilinear trend. The dorsal margin extends into a long and straight rostrum bearing many identical and forwards protuded suprarostal teeth. Rabadà (1993, p.358) pointed out in the examined specimens the presence of a rostrum with 30 small suprarostal teeth. From the analysis of the whole sample and above all the sample used for this study, it is difficult to observe and quantify the number of suprarostal teeth because of the fragility of the rostrum which is usually broken or badly preserved. Nevertheless, the analysis of nine specimens (LH98, LH219, LH1351, LH2974, LH1852, LH13043, LH13256 and above all LH1122 and LH1855) confir-

med the presence of at least 25 small identical and forwards protuded suprarostrals teeth, arranged along the whole rostrum, which seems to be strengthened by a thin longitudinal median carina extending from the base to the distal extremity. The ocular incision is narrow and shallow and the antennal and pterygostomial angles are not very marked. No traces of grooves, carinae and spines can be observed on the surface of the carapace.

Abdomen. The abdomen shows the typical, almost right-angle curvature of carideans between somites III-IV. Somites I-V have a subrectangular shape and uniform length. Somite II has a strongly subround pleura overlapping that of somites I and III. The pleurae of the other somites are rounded and strengthened by a thin marginal carina. The posterior margin of somite III is slightly sinuous, while that of somites IV-V is posteriorly projecting. Somite VI is strongly elongate, reaching twice the length of the other somites. The telson has a triangular shape and pointed distal extremity. The uropods, lacking any ornamentation, have the same length, a rounded distal extremity and are not longer than the telson. The exopodite shows a rounded diaeresis.

Cephalic appendages. Badly preserved in almost all specimens. The eye is supported by a short eye-stalk. The antennulae consist of three articuli: the 1st and the 2nd are thin and elongate, while the 3rd is short and stocky. It is impossible to assess the length of the antennular flagella. The scaphocerite has a triangular shape and pointed distal extremity. The carpocerite of the antennae has a subrectangular shape. A flagellum, almost as long as the body, is articulated to it.

Thoracic appendages. They are preserved only in eight specimens (LH219, LH1855, LH2875, LH2974, LH13043, LH14209, LH14294, LH14361). The 3rd maxilliped is not preserved. Pereiopods I-II, with thin articuli, have very small chelae with internal dactylus. Pereiopods III-V, with thin and elongate articuli, have a terminal dactylus and are about 1/3 longer than the first two pairs of pereiopods.

Abdominal appendages. They are visible in almost all specimens. The pleopods consist of a subrectangular sympodite to which two elongate multiarticulate flagella are articulated.



Fig. 2 - *Delclosia martinelli* Rabadà, 1993, carapace reconstruction, line drawing.

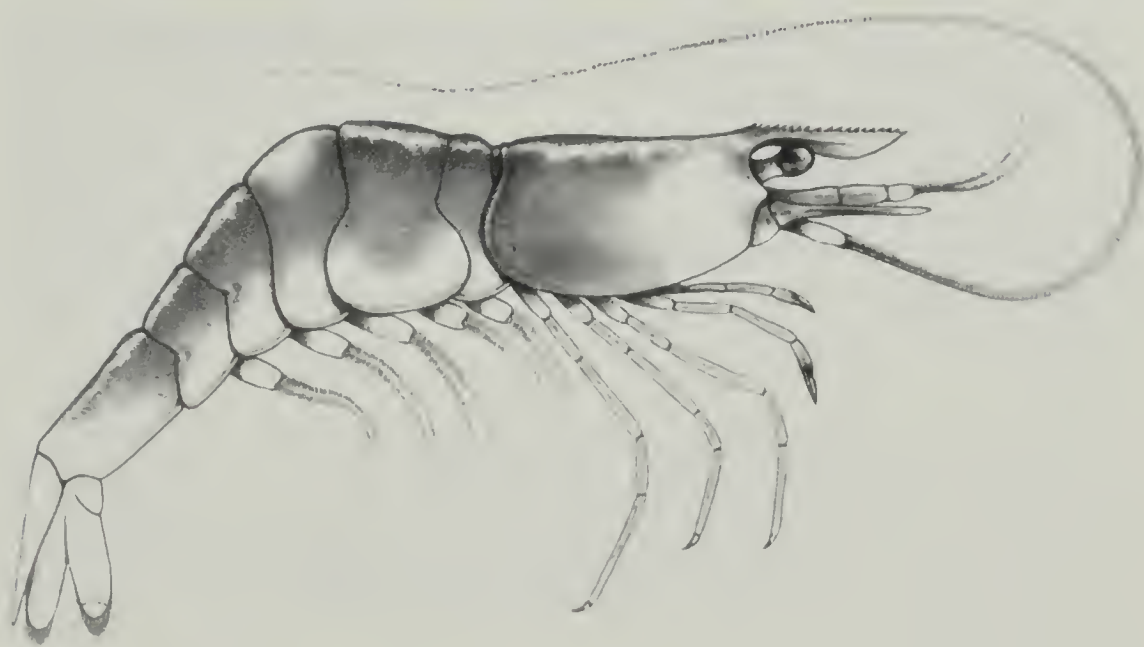


Fig. 3 - *Delclosia martinelli*, Rabadà, 1993, reconstruction.

Observations

Carideans are very rare in the fossil record and their morphological features are not well known because of their poor state of preservation.

The most ancient genera known to date, *Acanthinopus* Pinna, 1974 and *Leiothorax* Pinna, 1974, were discovered in the Calcare di Zorzino (Norian, Upper Triassic) of Bergamo Prealps (Cene, Seriana Valley - Bergamo, N Italy) (Pinna, 1974). Another form, *Pinnacaris* Garassino & Teruzzi, 1993, was described in the Argilliti di Riva di Solto (Sevatian, Upper Norian-Lower Rhaetian, Upper Triassic - depending on the authors) of Ponte Giurino (Imagna Valley - Bergamo, N Italy) (Garassino & Teruzzi, 1993).

Glaessner (1969) ascribed to Jurassic only the genus *Udorella* Oppel, 1862 (family Udorellidae Van Straelen, 1924). The same author ascribed also three *incertae sedis* Jurassic genera to carideans: *Blaculla* Münster, 1839, *Hefriga* Münster, 1839 and *Udora* Münster, 1839.

We presently know four species of Cretaceous carideans.

Martins-Neto & Mezzalana (1991a) found a few specimens of carideans in the Crato Member of Santana Formation (Lower Cretaceous) of Brazil. The perfect state of preservation of these specimens allowed the authors to describe the new genus *Beurlenia* (family Palaemonidae Rafinesque, 1815) with the species *B. araripensis*.

Roger (1946) described the new species *Notostomus cretaceus* on a sample of five specimens found in the Santonian (Upper Cretaceous) of Sahel Alma (Lebanon). This species was the subject of a recent review by Garassino (1994), who ascribed the species by Roger to the new genus *Odontochelion* (family Oplophoridae Dana, 1852).

Bravi & Garassino (in press) recently described on a sample of 14 specimens of the Lower Albian (Lower Cretaceous) of Pietraroia (Benevento, S Italy) the new genus *Parvocaris* with the species *P. samnitica* n.sp. (indeterminate family), while three specimens of the Middle Albian (Lower Cre-

taceous) of Petina (Alburni Mounts, Salerno - S Italy) were ascribed to the new genus *Alburnia* with the species *A. petinensis* n. sp. (family Palaemonidae Rafinesque, 1815).

Garassino & Ferrari (1992) reported the presence of only one specimen of caridean in the Senonian (Upper Cretaceous) of Trebiciano (Trieste, NE Italy) without ascribing it to a known family, genus and species. Garassino & Teruzzi (1995) recently reported the probable presence of a new caridean form in the Upper Hauterivian-Lower Barremian (Lower Cretaceous) of Vernasso (Udine, NE Italy).

At present, only four genera of carideans are known in the Tertiary deposits.

Four species belong to the genus *Bechleja* Housa, 1956, a typical form of freshwater deposits: *B. rostrata* Feldmann et alii, 1981 from the Eocene of the Green River Formation (Wyoming, USA); *B. inopinata* Hořsa, 1956 from the Oligocene of the Czechoslovakia; *B. bahiaensis* (Beurlen, 1950) and *B. robusta* Martins-Neto & Mezzalira, 1991 from the Oligocene of Brazil (Beurlen, 1950; Hořsa, 1956, Feldmann et alii, 1981; Martins-Neto & Mezzalira, 1991b).

In the Miocene deposits of N Caucasus (Russia) the three genera *Palaemon* Weber, 1795, *Pasiphaea* Savigny, 1816 and *Bannikovia* Garassino & Teruzzi, 1996 were described, with the species *P. mortuus* Smirnov, 1929, *P. mortua* Smirnov, 1929 and *B. maikopensis* Garassino & Teruzzi, 1996 (Smirnov, 1929; Garassino & Teruzzi, 1996) respectively.

Patricelli et alii (in press) recently ascribed a sample of over 40 complete and fragmentary specimens to the new species *Palaemon vesolensis* (family Palaemonidae Rafinesque, 1815), found in the Paleocene deposits of Vesole Mount (Salerno, S Italy).

On the grounds of what described, the genus *Delclosia* Rabadà, 1993 with the species *D. martinelli* Rabadà, 1993 not only represents the only freshwater caridean known to date in the Cretaceous deposits, but it also represents one of the few caridean forms known to date that can be ascribed with certainty to a known family by some characters. In fact, the review of this species pointed out some characters, partly described by Rabadà (1993) already, such as the rostrum with 25-30 suprarostreal teeth, pereopods I-II shorter than pereopods III-V, propodus of pereopods III-V slightly wider than carpus, and dactylus of pereopods III-V very short. These characters allow to ascribe the studied specimens to the family Atyidae de Haan, 1849, thus confirming the previous uncertain ascription suggested by Rabadà (1993).

At present, the family Atyidae de Haan, 1849 is known in the fossil record by five genera, one of which of uncertain Cretaceous age, *Atyoida* Beurlen, 1950, and four of Tertiary age, *Caridina* Leach, 1816, *Atya* Milne Edwards, 1837, *Atyaephyra* de Brito Capello, 1867 and *Dugastella* Bouvier, 1912. Since the knowledge on Beurlen's genus is restricted to a few characters, it is difficult not only to compare it with the species *D. martinelli* Rabadà, 1993, but also to ascribe it with certainty to carideans.

At present, four subfamilies belong to the family Atyidae de Haan, 1849: Atyinae de Haan, 1849, Caridellinae Holthuis, 1986, Paratyinae Holthuis, 1986 and Typhlatyinae Holthuis, 1986 (Holthuis, 1994), all inclu-

ding freshwater forms. It is very difficult to ascribe the Spanish species to one of these subfamilies, because the main characters of *D. martinelli* Rabadà, 1993, such as the rostrum with many suprarostreal teeth, pereopods I-II shorter than the others and the exopodite with diaeresis, are common to almost all genera belonging to these subfamilies. Moreover, the lack of more specific diagnostic characters, such as the number of gills and the presence or absence of exopodite on pereopods I-III, that can be observed in the living specimens but not in the fossil ones, rules out every opportunity of sure attribution.

Infraorder Astacidea Latreille, 1803
Family Astacidae Latreille, 1802
Genus *Austropotamobius* Skorikov, 1907

Austropotamobius llopisi (Via, 1971)
Figs. 4, 5, 6, 7, 8, 9, 12, 13

- 1971 - *Pseudastacus llopisi* - Via, p. 608, Figs. 2, 2a
1984 - *Pseudastacus llopisi* - Via, Barale et alii, p. 279
1988 - *Pseudastacus llopisi* - Via, p. 350, Fig. 339H
1988 - *Pseudastacus llopisi* - Via, Sanz et alii, p. 615
1993 - *Pseudastacus llopisi* - Via, Rabadà, p. 347, Figs. 1, 2

Diagnosis. Subrectangular carapace with a deep cervical groove extending into a not very marked antennal groove; long rostrum with one supra-rostral tooth in the proximal third; only one postorbital tooth at the base of the rostrum; chelae of pereopod I with a marked step in the proximal part of the index at the level of the articulation with the dactylus; subrectangular telson, longitudinally subdivided into two parts, with a strong spine in the lower part of the lateral margins and with a Y-shaped dorsal carinae system; exopodite with diaeresis.

Material. Over 800 complete and fragmentary specimens belong to the collection of the Autonomous University of Madrid and to the private collection of Mr. Armando Díaz-Romeral; 28 almost complete specimens most of which in perfect state of preservation were studied in detail in order to deepen the analysis on this species. This analysis has allowed to point out not only some characters not observed by Rabadà (1993), but also to describe again other characters badly described in the original description. 21 specimens are in dorsal view, 5 in lateral view and 2 in ventral view.

LH097, LH101, LH143, LH171, LH191, LH212, LH400, LH401, LH1179, LH2072, LH2097, LH2453, LH2468, LH2513, LH2708, LH2733, LH2894, LH13125, LH13586, LH14011, LH14233, LH14268, LH14295, LH14363, ADR18, ADR82, ADR NC1, ADR NC2

The following specimens were used for the new description of the species: LH212, LH401, LH1179, LH2894, LH14268, LH14363, ADR18, ADR82, ADR NC1, ADR NC2

Description. It is a medium-sized astacidean, with strong and strongly tubercolate exoskeleton, 2 to 6 cm in length.

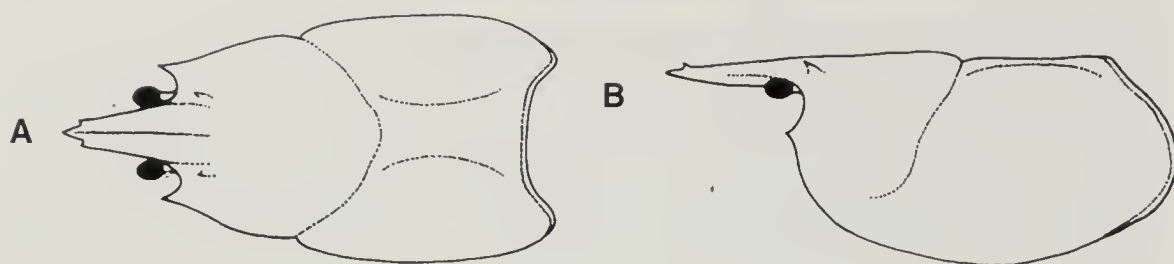


Fig. 4 - *Austropotamobius llopsi* (Via, 1971), carapace reconstruction in dorsal view (A) and in lateral view (B), line drawing.

Carapace. The carapace (Fig. 4A), in dorsal view in the larger part of the specimens, has a subtrapezoidal shape and it narrows slightly near the deep ocular incision. The lateral margins are rounded, while the posterior margin is anteriorly not very arcuate. The carapace (Fig. 4B), in lateral view, has a subrectangular shape and it gets slightly narrower toward the anterior margin for the slight curvature of the ventral margin. The dorsal margin is straight and bends near the deep cervical groove, it originates in the median part of the dorsal margin and it slightly degrades toward the antennal region, with a not very marked antennal groove. The posterior margin, strengthened by a thin marginal ridge, is sinuous, with a slight concavity in the lower third. The dorsal margin extends into a long rostrum, with a pointed distal extremity and with only one suprarostrum tooth in the distal part. The subrostral teeth are lacking. The rostrum is strengthened by a toothless thin median carina. A strong forwards protruded postorbital tooth is present at the base of the rostrum. The narrow and deep ocular incision ends with a strong antennal spine. The pterygostomial angle is not very pronounced. The branchiocardiac, postcervical and hepatic grooves are lacking. The carapace surface is strongly tubercolate.

Abdomen. The somites, strengthened by a thin longitudinal median carina, are of even length, are subrectangular in outline and narrow caudally. The dorsal surface of the somites is slightly tubercolate. Somite VI has two strong tubercles at the level of the articulation margin with the telson. The tail fan (Fig. 5) is well preserved in most specimens. The telson is subrectangular in shape, has a rounded distal extremity and is crossed by a Y-shaped thin dorsal carinae system: the longitudinal median carina extends along the

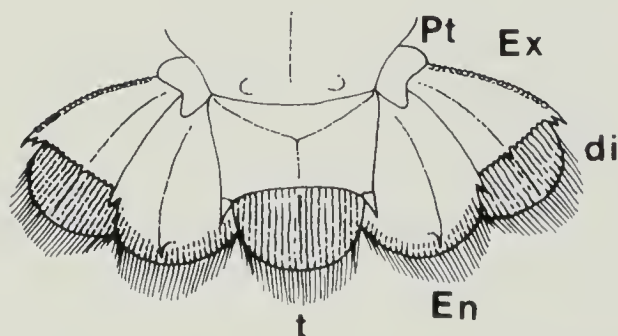


Fig. 5 - *Austropotamobius llopsi* (Via, 1971), tail fan reconstruction, line drawing.

whole telson, while the two lateral carinae originate from the upper tops of the lateral margins of the telson and they converge at the centre of the telson, joining the median carina at the level of the upper third. The lateral margins of the telson are characterized by a strong spine in the lower part, where a kind of transversal fold originates, breaking the telson into two almost identical parts: the rigid and strongly tubercolate upper part and the flexible and slightly tubercolate lower part. The uropods are as long as the telson and their surface is slightly tubercolate. The protopodite, subrectangular in outline, supports the exopodite. The exopodite is covered by a thin longitudinal median carina that extends along its whole length. At the level of the diaeresis the outside lateral margin of the exopodite, strengthened by a row of small tubercles, has two strong spines, the external one of which is more developed and elongate than the other. The diaeresis is straight with the upper margin strengthened by a row of small spines, the central one of which is more developed than the others. The endopodite is crossed along its whole length by a thin longitudinal median carina ending in a small spine. The outside lateral margin of the endopodite has a strong spine in the lower third. The lower margins of the telson and the uropods are finely fringed.

Cephalic appendages. The cephalic appendages are well preserved in almost all specimens. The eye is supported by a short eye-stalk. The antennulae consist of three segments: the 1st is thin and elongate, while the 2nd and the 3rd are short and stocky. The flagella of the antennulae are short. Two segments of the antennae can be observed: the thin and elongate merocerite and the short and stocky carpocerite. The flagella of the antennae are as long as the body. The laminar-shaped scaphocerite has a finely notched distal margin, while the outside margin is strengthened by a row of small tubercles. The dorsal surface of the segments of the antennulae, antennae and scaphocerite is slightly tubercolate.

Thoracic appendages. Well preserved in all specimens. The 3rd maxilliped, well preserved only in three specimens (LH101; LH14233; LH14268), preserves the last three spineless elements, narrowing toward the distal extremity. As Rabadà (1993) observed, the strongly developed pereopod I has a slight heterochely only in a few some specimens. The propodus of the chela (Fig. 6) is strong and elongate, with dactylus and index of the same length and slightly bent at the distal extremity. The internal margin of the index has a marked step in the proximal part, at the level of the articulation with the dactylus. This step is supplied by a variable number (from four to six) of flat and strong teeth. The median part of the index and the internal



Fig. 6 - *Austropotamobius llopsi* (Via, 1971), pereopod I without ornamentation, line drawing.

margin of the dactylus are characterized by strong and rounded teeth, getting gradually toward the distal extremity. The carpus, subrectangular in outline, is short and stocky and it has a well developed spine in the internal lateral margin, at the level of the articulation with the propodus, while the merus is strong and elongate. The internal lateral margin of the merus, carpus and propodus is strengthened by a row of strong teeth rounded at the distal extremity and forwards protuded. These teeth are present also on the outside lateral margin of the dactylus, stopping almost at the level of the distal extremity. The morphometric and morphological analysis of the studied specimens has pointed out an interesting datum: the specimens with a total length of the body varying from 2 to 2.5 cm (LH143, LH171, LH2097, LH2468, LH2513, LH2733) have no teeth along the internal margin of the dactylus and index. On the contrary such character is present in the specimens with a total length varying from 3 to 6 cm. The appearance of this character might be connected to a specific ontogenetic stage. Pereiopods II-III have small chelae with internal dactylus, while pereiopods IV-V have a terminal dactylus. The dorsal surface of pereiopod I is strongly tubercolate, while that of pereiopods II-V is finely tubercolate.

Abdominal appendages. Pleopods are observed only in a few specimens (ADR NC2; LH400; LH14011). They consist of a subrectangular sym-podite to which two long multiarticulate flagella are articulated.

Observations

Via (1971) ascribed ten macruran decapod crustaceans, found in Montsec outcrops (Lleida, Barcelona), to the genus *Pseudastacus* Oppel, 1862, establishing the new species *P. llopisi*. As Rabadà (1993) reported, Via justified the ascription to this genus by some common characters, observed in the studied specimens, such as the chela of pereiopod I with straight dactylus and index, deep postcervical groove, triangular rostrum with pointed distal extremity and with lateral teeth at the base, tubercolate carapace, moderately large and thin antenna and large antennular peduncle. This ascription was further confirmed by the fact that the species *P. llopisi* Via, 1971 was established when the lithographic limestone of Montsec was thought Jurassic in age (Tithonian), marine and coeval to Solnhofen outcrop.

However, if Rabadà (1993, pag. 352) already criticized the ascription of this species to Oppel's genus, three observations mentioned here led the author to confirm the previously expressed doubt on the exact ascription of *P. llopisi* Via, 1971 to the genus *Pseudastacus* Oppel, 1862:

- the careful reading of the original description of *Pseudastacus* Oppel, 1862 with the type-species *P. pustulosus* Oppel, 1862 (Oppel, 1862, pag. 43, 44, Tab. 10 Figs. 4, 5, Tab. 11 Fig. 1).

- the discovery of a rich sample of specimens of the species *P. llopisi* Via, 1971 in Las Hoyas outcrop.

- the new geological age of Montsec outcrops, ascribed to the Lower Cretaceous (Upper Berrisian-Lower Valanginian) and considered of a freshwater and not marine origine.

This doubt would also be supported not only by the incomplete original description of *Pseudastacus* Oppel, 1862, but above all by the observation of some characters, such as the rostrum with supra- and subrostral

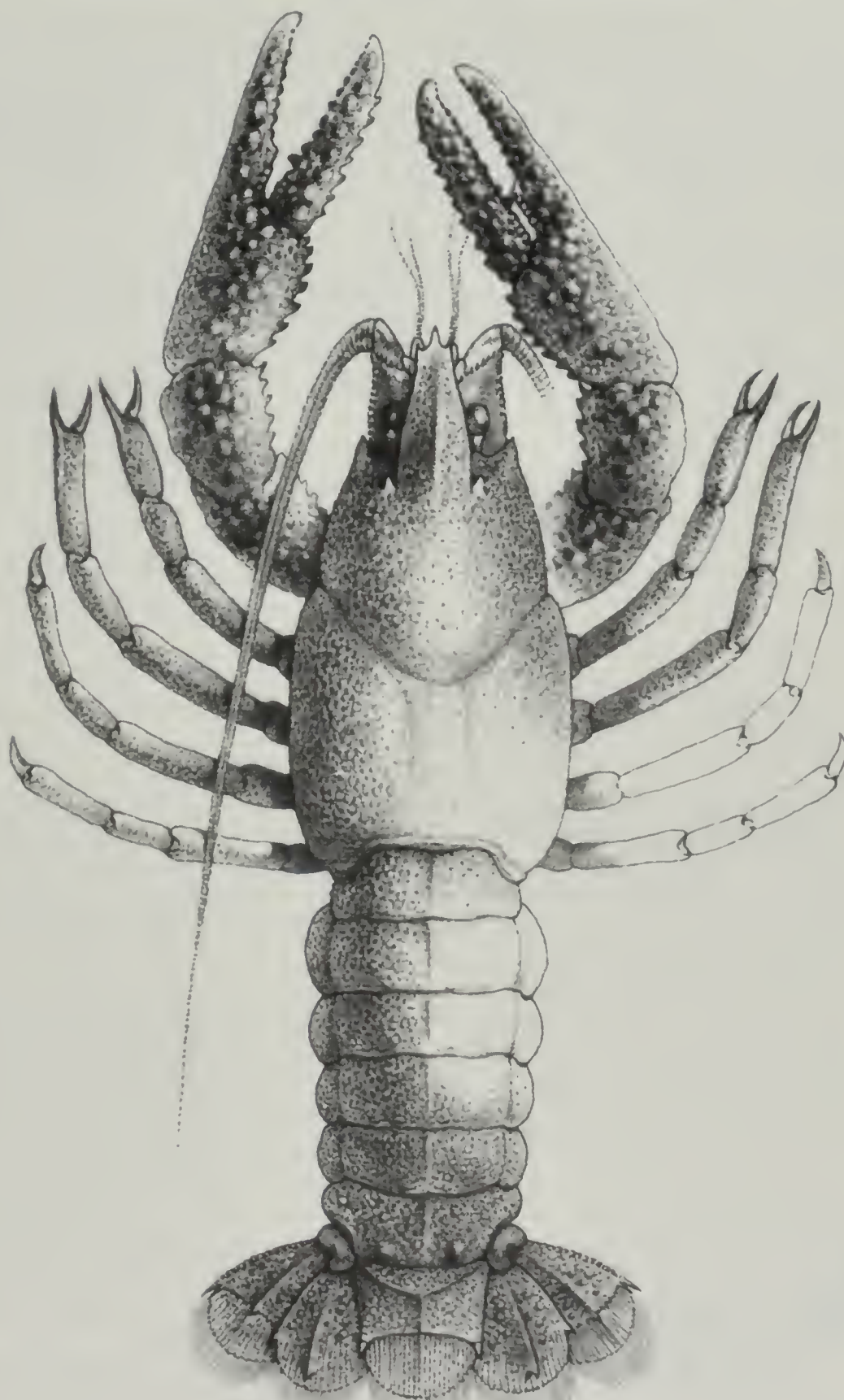


Fig. 7 - *Austropotamobius llopsi* (Via, 1971), reconstruction.

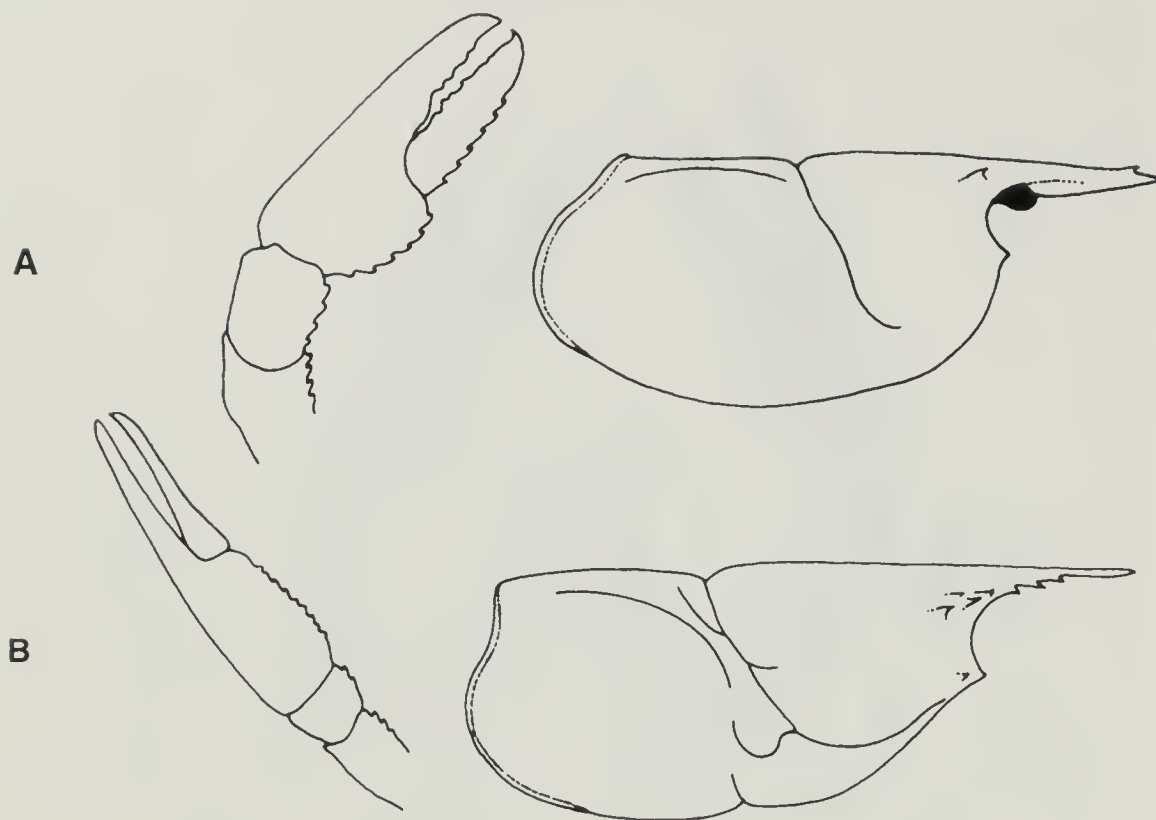


Fig. 8 - Comparison between the carapaces and chelae of pereiopod I of *Pseudastacus llopisi* Via, 1971 (A) and *Pseudastacus pustulosus* Oppel, 1862 (B).

teeth, pereiopod I with straight dactylus and index and the deep cervical groove, which can be observed in many genera belonging to the infraorder Astacidea Latreille, 1803. Since the above-mentioned characters are not peculiar of the genus *Pseudastacus* Oppel, 1862 it is still difficult to systematically locate it (Glaessner, 1969), even if Oppel (1862) ascribed this genus to the family Nephropidae Dana, 1852.

The revision of the species *P. llopisi* Via, 1971 allowed to point out new characters and to better describe other ones, thus allowing a comparison with the type-species *P. pustulosus* Oppel, 1862. In particular, the comparison between the carapace and pereiopod I of the two species (Fig. 8) definitively rules out a possible ascription of Via's species to the genus *Pseudastacus* Oppel, 1862. In fact, *P. llopisi* Via, 1971 has not a rostrum with subrostral teeth and gastro-orbital, postcervical, branchiocardic and hepatic grooves; on the contrary these characters are present in the German species. Moreover, unlike Oppel's species, in *P. llopisi* Via, 1971 the chela of pereiopod I has strong teeth along the internal margin of the dactylus and the index and a marked step in the proximal part of the index, at the level of the articulation margin with the dactylus.

As previously mentioned, the marine origin and the Jurassic age of Montsec outcrops led Via (1971) to ascribe the studied specimens to the genus *Pseudastacus* Oppel, 1862 and to the family Nephropidae Dana, 1852 including only marine forms. The lack of some typical characters of this fa-

mily in Las Hoyas specimens, such as the rostrum with subrostral teeth, the pointed abdominal pleurae and the undivided telson with two strong spines at the distal extremity, quite certainly exclude their ascription to this family. However, as Rabadà (1993) already mentioned, the carapace with deep cervical and subcervical grooves, the rounded abdominal pleurae and the telson divided into two parts by a transversal fold allow to ascribe the studied specimens to the family Astacidae Latreille, 1802 including only freshwater forms.

Since we exclude that the Montsec and Las Hoyas specimens belong to the genus *Pseudastacus* Oppel, 1862, it is necessary at least to explain their new generic position within the family Astacidae Latreille, 1802.

As far as this position is concerned, some well preserved characters were observed in the studied specimens, such as the carapace, the chela of pe-

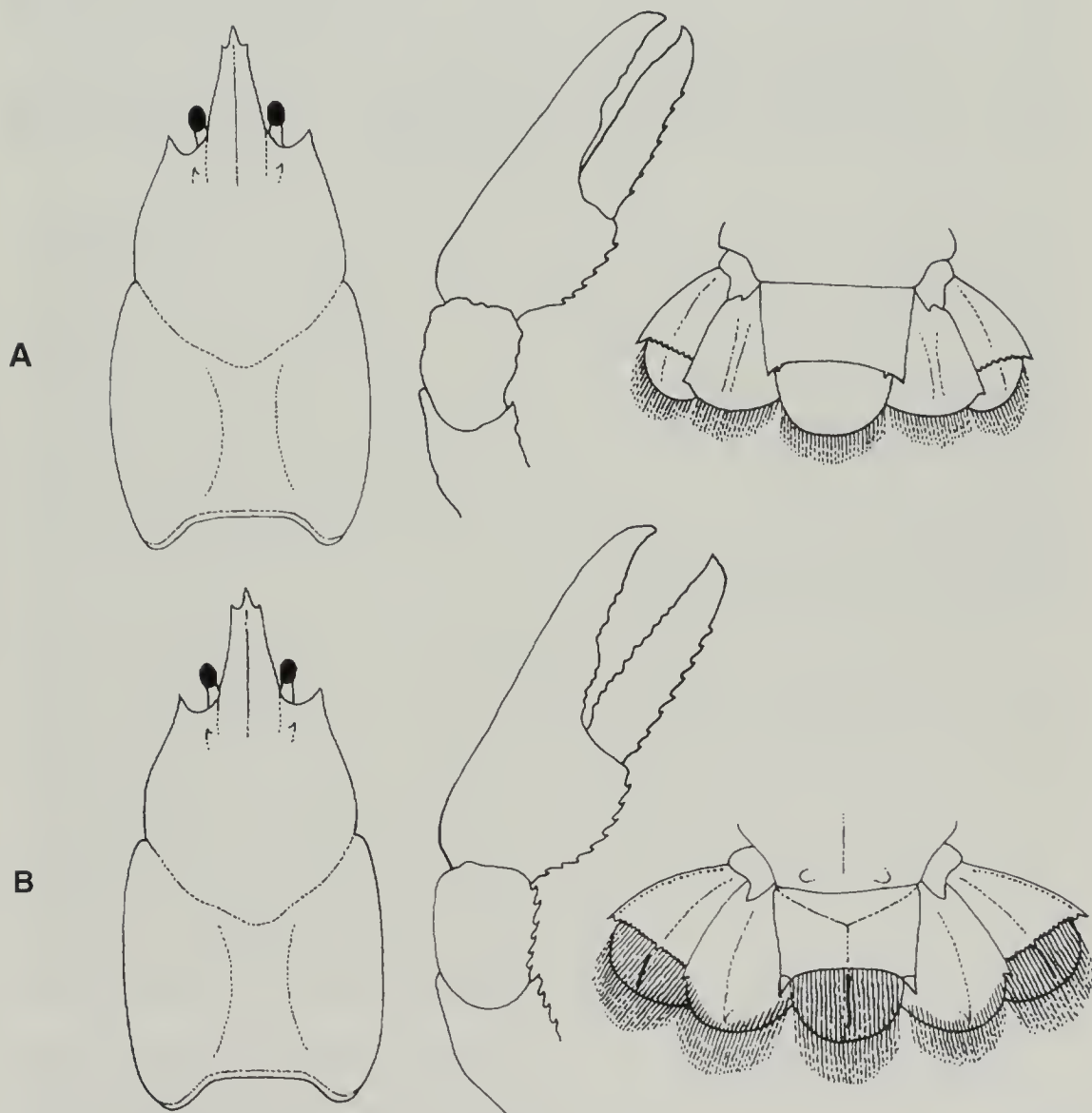


Fig. 9 - Comparison between the carapaces, chelae of pereopod I and tail fans of *Austropotamobius pallipes italicus* (Faxon) (A) and *Austropotamobius llopisi* (Via, 1971) (B).

pereiopod I and the tail fan. These characters allowed to carry out a comparative analysis on two living genera: *Astacus* Fabricius, 1775 and *Austropotamobius* Skorikov, 1907.

The genus *Astacus* Fabricius, 1775 is known, even if with some doubts by Glaessner (1969), starting from the Lower Cretaceous (?) with two species: *A. licenti* Van Straelen, 1928 and *A. spinirostrius* Imaizumi, 1938 from Eastern Mongolia (Van Straelen, 1928). Due to the bad state of preservation of these two fossil species, the characters of this genus have been inferred from living forms. Froggia (1978), points out the main characters of this genus: subrectangular carapace with one suprarostal tooth in the distal part; presence of two postorbital teeth; deep cervical groove with one or two postcervical spines; well developed chela of pereiopod I lacking the marked step in the internal margin of the index, at the level of the articulation with the dactylus; telson subrectangular in outline with a strong median spine on the lateral margins and subdivided into two more or less identical parts the upper one of which is fixed and the lower one is mobile; exopodite with rounded diaeresis.

I think that two characters observed in the studied specimens allow to exclude the ascription to this genus: the presence of only one postorbital tooth and the chela of pereiopod I with a marked step in the internal margin of the index at the level of the articulation with the dactylus.

The genus *Austropotamobius* Skorikov, 1907, widespread in almost all Europe, from England to Italy and from Portugal to Switzerland does not include known forms in the fossil record. Froggia (1978) points out the main characters of this genus: subrectangular carapace with one suprarostal tooth in the distal part; presence of only one postorbital tooth; deep cervical groove; well developed chela of pereiopod I with a marked step in the internal margin of the index at the level of the articulation with the dactylus; telson with a strong spine in the lower part of the lateral margins and subdivided into two more or less identical parts, the upper one of which is fixed and the lower one is mobile; exopodite with one spine on the outside margin, at the level of the rounded diaeresis; endopodite with a spine in the lower third of the outside margin.

The comparison with this genus has pointed out some common characters (Fig. 9) that allow to ascribe the Montsec and Las Hoyas species to the genus *Austropotamobius* Skorikov, 1907. In fact, the studied specimens have a rostrum with one suprarostal tooth in the distal part, only one postorbital tooth, chela of pereiopod I with a marked step in the internal margin of the index, at the level of the articulation with the dactylus, telson subdivided into two parts and with a strong spine in the lower part of the lateral margins, outside lateral margin of the exopodite with a strong spine at the level of the upper margin of the diaeresis, and endopodite with a spine in the lower third of the lateral margin. Unlike the living genus, the fossil specimens have a telson with a Y-shaped dorsal carinae system and uropods with marked median longitudinal carinae.

Therefore *A. llopisi* (Via, 1971) represents the first fossil species of this genus and it is the second Mesozoic freshwater record of a reptant decapod crustacean after the discovery of one erymid in the Upper Triassic lacustre environments of Arizona (Miller & Ash, 1988).

Palaeoecology

The many sedimentological data obtained by the study of Las Hoyas outcrop (Meléndez et alii, 1989 and Fregenal, 1991) and the biological observations carried out on lacustre environments (Margalef, 1983), lead to think that the species *A. llopisi* (Via, 1971) led an essentially bentonic life, living in the photic and oxygenated zone, where the charophytes thrived (Meléndez et alii, 1989, Fregenal Martínez, 1991 e Mercadé, 1991). The presence in the outcrop of one only reptant species with a high number of specimens (almost 800, to which a certain number of slabs preserving many specimens or even plagues must be added) could be connected to the low specific diversity generally found in a eutrophic lake. The Las Hoyas lake had to be eutrophic, because of the abnormal development of carophytes taking place in certain moments of the year. An essentially necrophagous and omnivorous diet, similar to that of living astacideans, probably helped this species in an opportunist strategy which partly reflects its clear numerical supremacy on carideans.

As far as the other species present in the outcrop is concerned, it is believed that *D. martinelli* Rabadà, 1993, as the living representatives of the family Atyidae de Haan, 1849, also lived in the photic zone, using algae as a protection and feeding on plankton.

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Photos by Luciano Spezia; detailed drawings by Fabio Fogliazza.



Fig. 10 - *Delclosia martinelli* Rabadà, 1993, holotype, n. cat. LH 219, photo and reconstruction (x 4).

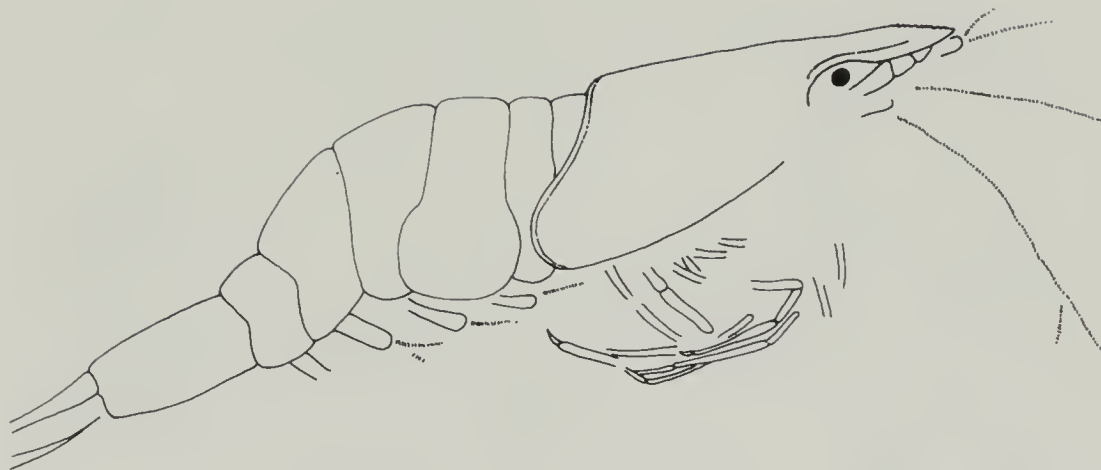
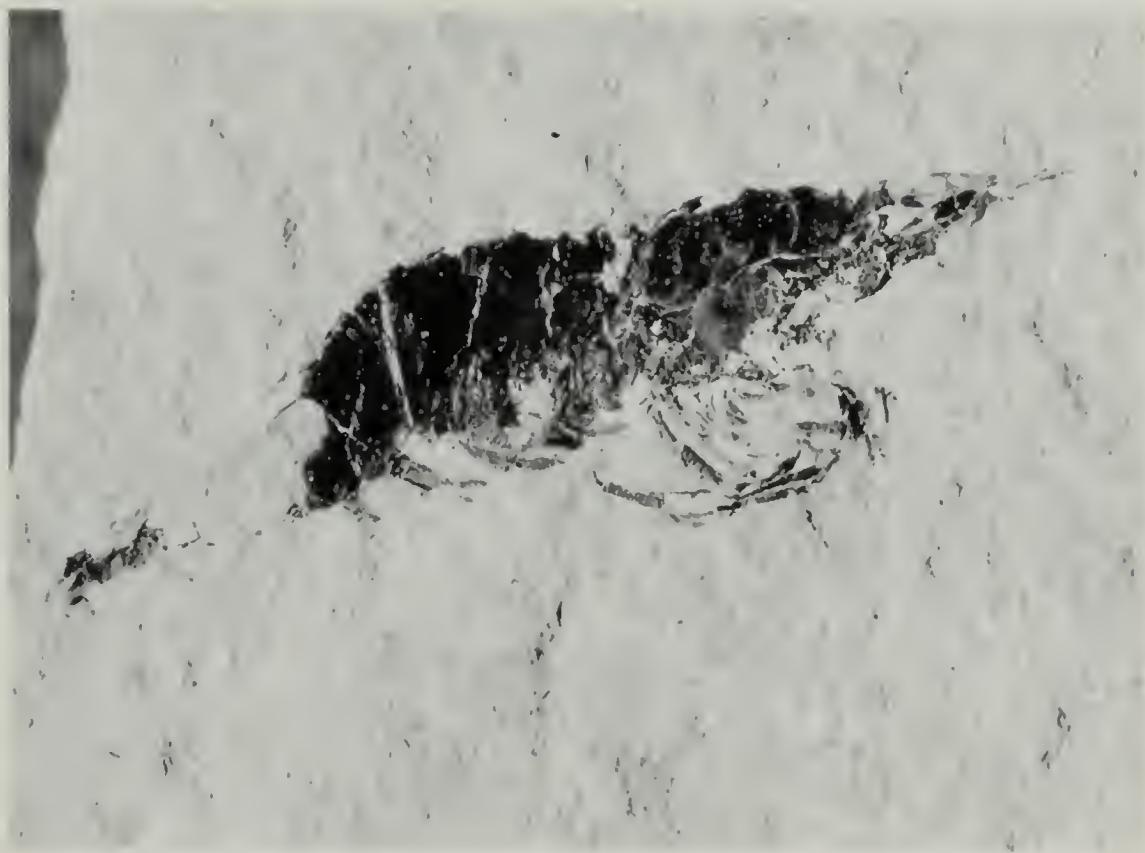


Fig. 11 - *Delclosia martinelli* Rabadà, 1993, n. cat. LH 13043, photo and reconstruction (x 6).

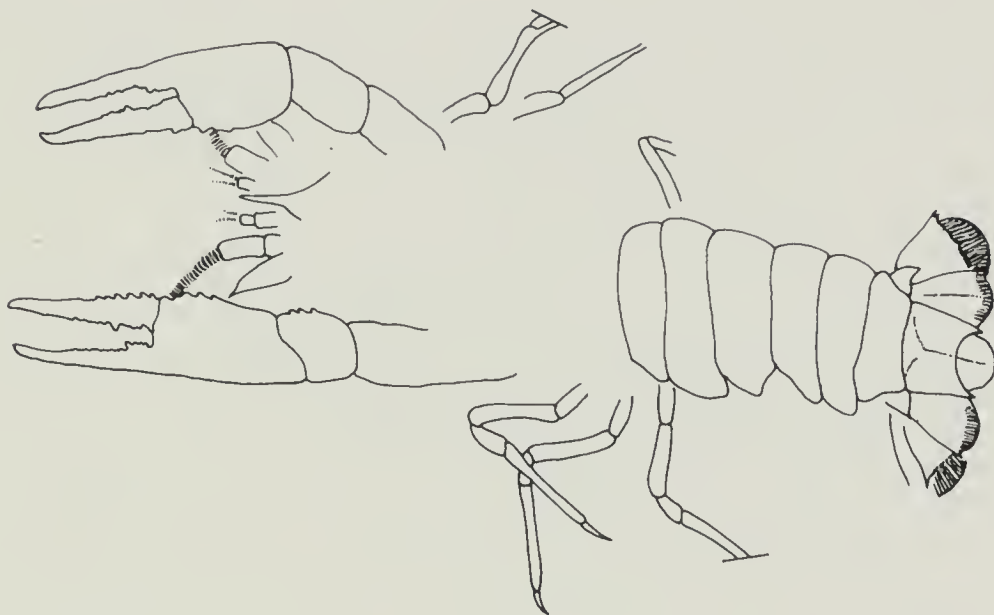
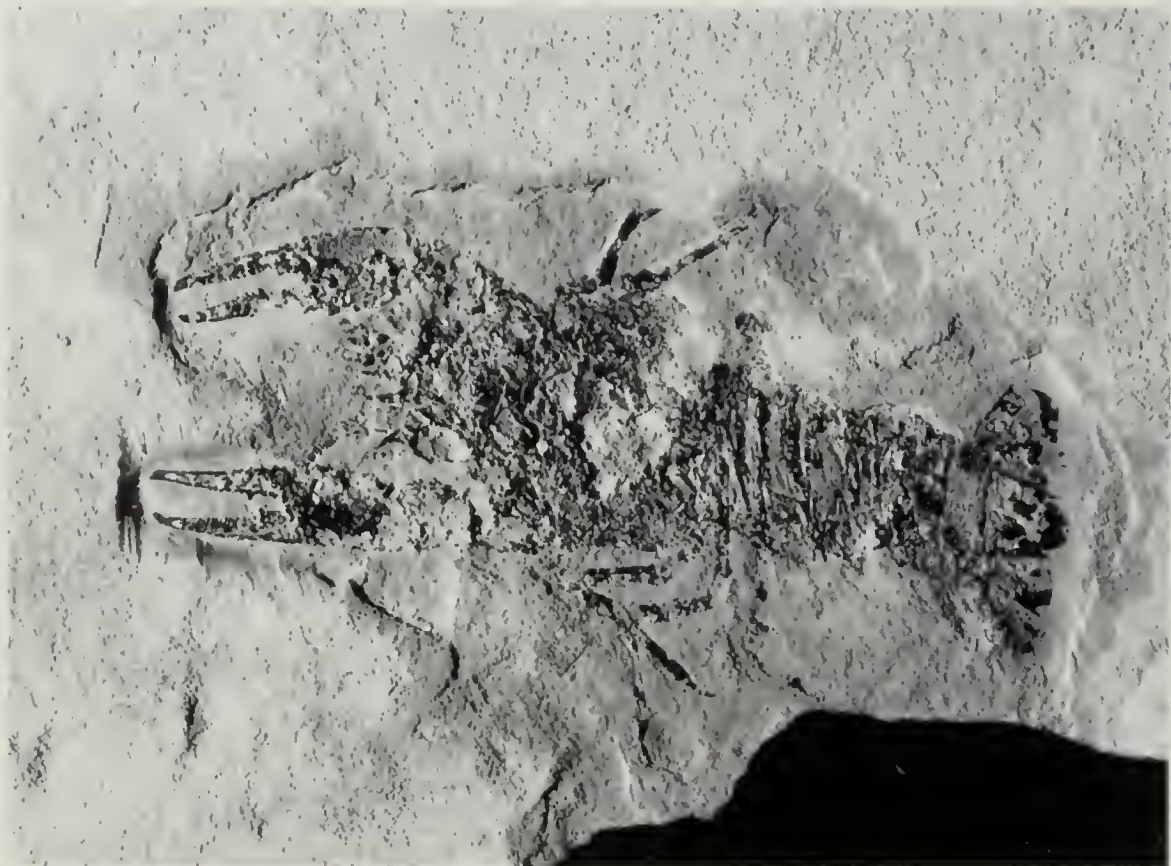


Fig. 12 - *Austropotamobius llopisi* (Via, 1971), n. cat. ADR 18, photo and reconstruction (x 1.7).

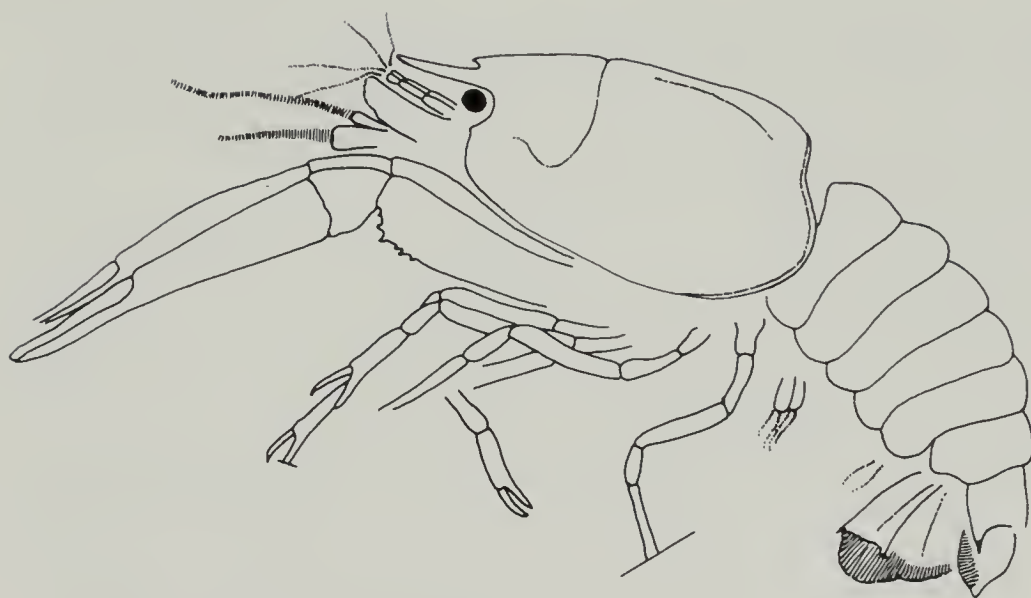
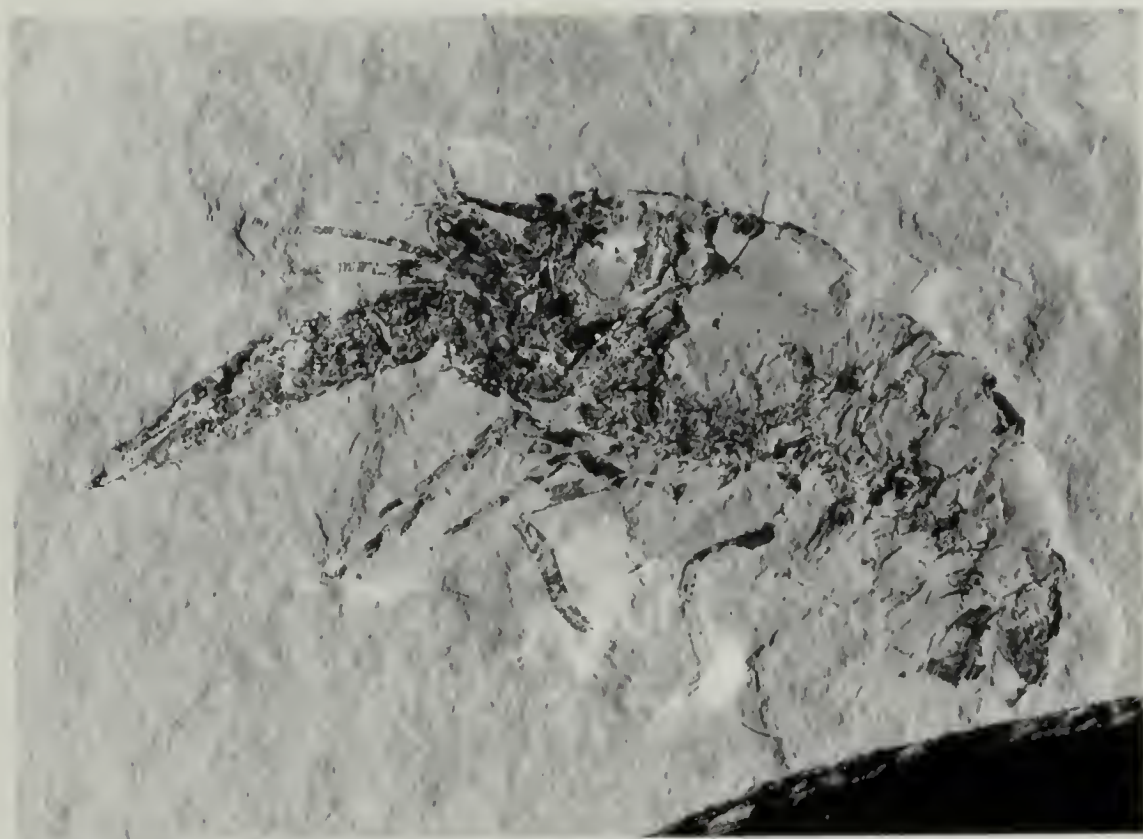


Fig. 13 - *Austropotamobius llopsi* (Via, 1971), n. cat. ADR NC2, photo and reconstruction (x 1.4).

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